

We Claim:

1. A chemical-mechanical manufacturing process for planarizing or polishing semiconductor, metal, dielectric, glass, polymer, optical, and ceramic materials, the process comprising:
 - a) providing a workpiece;
 - b) providing a chemical-mechanical planarizing colloidal slurry, said slurry comprising non-agglomerated multi-component particles of a mixed-oxide, oxyfluoride, or oxynitride composition, each particle exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than the pH of dispersed particles in solution.
 - c) abrading a surface of said workpiece with said multi-component particles.
2. The process according to claim 1, wherein said particle surface chemistry is modified relative to the surface chemistry performance of the individual, original base constituents of said mixed-oxide particle.
3. The process according to claim 2, wherein said isoelectric point of said multi-component particle is displaced toward an alkaline pH value relative to the surface chemistry performance of the individual, original base constituents of said particle.
4. The process according to claim 1, wherein said particle has an isoelectric point (pH_{IEP}) greater than or equal to about 5-6 with a stabilized particle dispersion at pH values of interest for CMP operations.
5. The process according to claim 1, wherein said isoelectric point of said multi-component particle is greater than or equal to about pH 7.
6. The process according to claim 1, wherein said multi-component particles have a composition $\alpha_x\beta_y$, wherein α is a transition metal, metalloid, alkaline earth, rare earth, or alkali element, or a plurality combination thereof, β is O and/or N, and x and y \neq 0.

7. The process according to claim 6, wherein SiAlON is a plurality combination.
8. The process according to claim 6, wherein quantities of glass-formers/modifiers comprising Al_2O_3 , B_2O_3 , CeO_2 , GeO_2 , P_2O_5 , PbO_2 , Ta_2O_5 , TiO_2 , ZrO_2 , are added to silicate materials to adjust the surface chemistries and hardness of said particles.
9. The process according to claim 6, wherein for non-silicate-based materials α is selected from: Al, As, B, Ca, Co, Ce, Cr, Cu, Er, Fe, Ga, Ge, In, K, La, Li, Mg, Mn, Na, Ni, P, Pb, Pr, Sb, Sn, Ta, Ti, Tl, Tm, V, W, Y, Yb, Zn, and Zr.
10. The process according to claim 1, wherein said mixed-oxide components include $\text{CeO}_2\text{-ZrO}_2$; $\text{CeO}_2\text{-Al}_2\text{O}_3$; $\text{GeO}_2\text{-SiO}_2$; $\text{GeO}_2\text{-Al}_2\text{O}_3\text{-SiO}_2$; $\text{Al}_2\text{O}_3\text{-SiO}_2$; $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$; $\text{P}_2\text{O}_5\text{-SiO}_2$, $\text{TiO}_2\text{-SiO}_2$, $\text{Ta}_2\text{O}_5\text{-SiO}_2$, $\text{Sb}_2\text{O}_3\text{-SiO}_2$, $\text{Sb}_2\text{O}_3\text{-Al}_2\text{O}_3\text{-}\alpha\text{O-SiO}_2$, wherein $\alpha = \text{Li, Na, K, Rb, Cs}$; $\beta\text{O}_a\text{-Al}_2\text{O}_3\text{-SiO}_2$, wherein $\beta = \text{Be, Mg, Ca, Ba, Sr}$, and $a \neq 0$; $\text{MgO-Al}_2\text{O}_3$; or such compositions doped with ~ 1 or 3-15 wt% F.
11. The process according to claim 1, wherein said abrasive has a multi-component composition comprising a combination of constituents selected from either SiO_2 , Al_2O_3 , B_2O_3 , and at least two or optionally three other oxides.
12. The process according to claim 1, wherein said mixed-oxide particle comprises in weight percent on an oxide basis, about 30-99% SiO_2 , 1-37% Al_2O_3 and at least one of the following: 0-70% Li_2O , 0-70% Na_2O , 0-70% K_2O , 0-70% BeO , 0-70% MgO , 0-70% CaO , 0-70% SrO , 0-70% BaO , 0-70% SbO_2 , 0-70% SnO_2 , 0-70% B_2O_3 , 0-70% GeO_2 , 0-70% CuO , 0-70% CuO_2 , 0-70% P_2O_5 , 0-70% PbO_2 , 0-70% Ta_2O_5 , 0-70% TiO_2 , 0-70% CeO_2 , 0-70% ZrO_2 , and/or 0-20% F, either alone or in combinations thereof.
13. The process according to claim 1, wherein said mixed-oxide particle includes at least three constituents selected from either SiO_2 - or Al_2O_3 -derivatives doped with metalloid, transition metals, alkali, alkaline earth, or rare earth components.

14. The process according to claim 1, wherein said particles are fumed silicate particles.
15. The process according to claim 1, wherein said multi-component particle has a pre-selected surface chemistry and hardness tailored to said workpiece surface.
16. The process according to claim 1, wherein said multi-component particle has at least two components, and with a particle size in the range of about 1–30 nanometers.
17. The process according to claim 1, wherein said multi-component particle has at least three components, and a particle size in the range of about 1-500 nanometers.
18. The process according to claim 17, wherein said multi-component particle has at least three components, and each with a particle size in the range of about 1-200 nanometers.
19. The process according to claim 1, wherein said multi-component particle has at least three components, and a particle size in the range of about 1-150 nanometers.
20. The process according to claim 19, wherein the size of said multi-component particles range from about 10 nm to up to about 150 nm.
21. The process according to claim 1, wherein said multi-component particles each has either a spherical, near-spherical, elongated, or amorphous morphology.
22. The process according to claim 1, wherein said multi-component particles are formed according to a flame hydrolysis process.
23. The process according to claim 1, wherein said multi-component particles are formed according to a sol-gel process.

24. The process according to claim 1, wherein said multi-component particles are dispersed in either an aqueous or non-aqueous suspension.
25. The process according to claim 1, wherein said multi-component particles are either oxyfluoride or oxynitride compositions.
26. The process according to claim 1, wherein said workpiece has a non-planarized surface.
27. The process according to claim 1, wherein providing a workpiece includes providing a semiconductor integrated circuit workpiece having a metallized interconnection structure.
28. The process according to claim 26, wherein providing a workpiece includes providing a semiconductor integrated circuit silicon wafer with a lithographic integrated circuit pattern and depositing at least one metallized interconnection layer.
29. The process according to claim 1, wherein providing a workpiece includes providing a semiconductor integrated circuit workpiece having an interlevel dielectric structure.
30. The process according to claim 28, wherein providing a workpiece includes depositing an interlevel dielectric material on a semiconductor integrated circuit workpiece.
31. A method for using a CMP slurry solution, the method comprising providing a solution of multi-component particles, said particles having a composition comprising mixed 1) metal or metalloid oxides, 2) oxyfluorides, or 3) oxynitrides, each grouping (1, 2, or 3) individually alone or in combination thereof, said particles exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than or equal to about 5-6 with a stabilized particle dispersion at pH values of interest

for CMP operations; dispersing said particles in a slurry; and applying said slurry to a workpiece.

32. A CMP slurry solution for planarizing and polishing semiconductor materials, the slurry comprising colloidal particles with a composition comprising mixed 1) metal or metalloid oxides, 2) oxyfluorides, or 3) oxynitrides, each grouping (1, 2, or 3) individually alone or in combination thereof, said particles exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than the pH of dispersed particles in solution.

33. The solution according to claim 32, wherein pH_{IEP} is greater than or equal to about 5-6 with a stabilized particle dispersion at pH values of interest for CMP operations.

34. The solution according to claim 32, wherein said CMP operations have a pH value between about 2-4.

35. The solution according to claim 32, wherein said isoelectric point is greater than or equal to about pH 6.5, when said CMP operations have a pH value between about 2-5.

36. The solution according to claim 32, wherein said isoelectric point is greater than or equal to about pH 7, when said CMP operations have a pH value between about 2-6.

37. The solution according to claim 32, wherein said particles have a mixed-oxide composition of either: (a) at least two metal-oxide components with a particle size in the range of about 1–30 nanometers, (b) at least three components with a particle size in the range of about 1-500 nanometers, or (c) a combination of (a) and (b), wherein said particle chemistry agglomeration resistant upon dispersion under predetermined pH conditions as employed in said planarizing or polishing operations, dispersed in a semiconductor processing slurry solvent.

38. The solution according to claim 32, wherein said colloidal particles are multi-component, mixed-oxide particles, each exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than or equal to about 6 with a reduced tendency to agglomerate at pH values of interest for CMP operations.
39. The solution according to claim 32, wherein said multi-component particles are either oxyfluoride or oxynitride compositions.
40. The solution according to claim 32, wherein said semiconductor materials include: single crystal silicon, metals, dielectric materials, and metal oxides.
41. The solution according to claim 32, wherein said semiconductor metal materials include an integrated circuit film of: aluminum alloy, copper, nickle, tungsten, tungsten silicide, titanium, titanium nitride, tantalum, tantalum nitride, or Ta_2O_5 .
42. The solution according to claim 32, wherein said semiconductor processing slurry is an aqueous solvent.
43. The solution according to claim 32, wherein said semiconductor processing slurry is a non-aqueous solvent.
44. The solution according to claim 32, wherein the CMP slurry provides film removal rates, independent of solid-loading, that are greater than about $0.5 \mu\text{m}/\text{minute}$ for metallic copper layer.
45. The solution according to claim 44, wherein the solution has a solid-loading with weight percent level in the range of about 1 to 10 wt. %.
46. The solution according to claim 45, wherein the solution has a solid-loading with weight percent level in the range of about 1 to 6 wt. %.

47. A CMP slurry solution for planarizing and polishing optical materials, the slurry comprising colloidal particles with a composition comprising mixed 1) metal or metalloid oxides, 2) oxyfluorides, or 3) oxynitrides, each grouping (1, 2, or 3) individually alone or in combination thereof, said particles exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than the pH of dispersed particles in solution.

48. The solution according to claim 47, wherein said pH_{IEP} is greater than or equal to about 5-6 with a stabilized particle dispersion at pH values of interest for CMP operations.

49. The solution according to claim 47, wherein said particles have a mixed-oxide composition of either: (a) at least two metal-oxide components with a particle size in the range of about 1–30 nanometers, (b) at least three components with a particle size in the range of about 1-500 nanometers, or (c) a combination of (a) and (b), wherein said particle chemistry is agglomeration resistant upon dispersion under predetermined pH conditions as employed in said planarizing or polishing operations.

50. The solution according to claim 47, wherein said colloidal particles are multi-component, mixed-oxide particles, each exhibiting a modified surface chemistry performance and having an isoelectric point (pH_{IEP}) greater than or equal to about 6 with a reduced tendency to agglomerate at pH values of interest for CMP operations.

51. The solution according to claim 47, wherein said isoelectric point is greater than or equal to about pH 7.

52. The solution according to claim 47, wherein said optical materials comprise a glass, a metallic oxide crystal, a fluoride crystal, and a polymer-based material.

53. The solution according to claim 52, wherein said glass includes silicates, borosilicates, boroaluminosilicates, aluminosilicates, chalcogenides, chalcogenides, chalcogenides, and halides.

54. The solution according to claim 52, wherein said oxide crystal includes Al_2O_3 (sapphire) and SiO_2 (quartz) crystals.
55. The solution according to claim 52, wherein said fluoride crystal includes LiF , BeF_2 , MgF_2 , CaF_2 , SrF_2 , and BaF_2 .
56. The solution according to claim 47, wherein said optical material comprises a surface of a visual display unit.
57. The solution according to claim 47, wherein said optical material comprises a lens, microlens, array of lenses or microlenses, or grating.
58. The solution according to claim 47, wherein said optical material comprises an optical waveguide.
59. The solution according to claim 47, wherein said particles are dispersed in an aqueous solvent.
60. The solution according to claim 47, wherein said particles are dispersed in a non-aqueous solvent.
61. The solution according to claim 47, wherein said multi-component colloidal particles have a composition of mixed-oxides, in weight percent, comprising about: 30-99% SiO_2 , 1-37% Al_2O_3 , and at least one of the following: 0-70% Li_2O , 0-70% Na_2O , 0-70% K_2O , 0-70% BeO , 0-70% MgO , 0-70% CaO , 0-70% SrO , 0-70% BaO , 0-70% SbO_2 , 0-70% SnO_2 , 0-70% B_2O_3 , 0-70% GeO_2 , 0-70% CuO , 0-70% CuO_2 , 0-70% P_2O_5 , 0-70% PbO_2 , 0-70% Ta_2O_5 , 0-70% TiO_2 , 0-70% CeO_2 , 0-70% ZrO_2 , and/or 0-20% F, either alone or in combinations thereof.
62. The solution according to claim 47, wherein said multi-component particles are either oxyfluoride or oxynitride compositions.

63. The solution according to claim 47, wherein said multi-component particles each has either a spherical, near-spherical, elongated, or amorphous (non-crystalline) morphology.
64. The solution according to claim 47, wherein said multi-component particles have an average dimension ranging from about 1 nm to about 150 nm.
65. The solution according to claim 47, wherein said multi-component particles, in solution, exhibit stable dispersion performance, without agglomerating to each other, at pH values < 5 .